Title of thesis: Prevalence of Sensory Processing Pattern Deficits in Children with Spastic Cerebral Palsy in Delhi NCR region and efficacy of Vestibular Stimulation Therapy in improving motor function in these children.

Introduction:

Sensory processing is the neurobiological process which includes registration and manipulation of sensory input. The process by which we can receive the stimuli from the environment and process the stimuli into the action is known as the sensory processing. There are six senses which we can feel from our environment that are smell, visual, taste, touch and hear. There are mainly four sensory processing pattern which are low registration, sensory seeking, sensory sensitivity and sensory avoiding (Dunn, 2014). And when these four factors are imbalanced then there is occurrence of sensory processing deficits. In children, sensory processing skill are impaired in which the children are unable to perform various daily tasks. Worldwide, there are 60-90% children which are suffering from sensory processing pattern deficits. Different assessment tools are used to treat sensory processing deficits that are sensory profile 2 (SP 2), sensory integration and praxis test (SIPT), sensory processing measure (SPM), evaluation in aryes sensory integration (EASI) (Passarello et al., 2022). Treatment are available for sensory processing deficits that are sensory integration therapy. The purpose of the sensory integration therapy is to use controlled sensory stimuli to facilitate an adaptive motor response. Through better integration of sensory information, sensory integration therapy promotes social interaction, academic performance, and independence. It also increases sensory modulation, which is linked to behavior and attention (Kanto et al., 2022).

Cerebral palsy (CP) is the irreversible neurological condition which is caused by nonprogressive brain injury (Pavão et al., 2021). There are different types of cerebral palsy but mainly spastic cerebral palsy is most common in which there is spasticity occur in muscles (Cans, 2000). There is various rehabilitation treatment available for cerebral palsy that are focus on their overall development and participation at societal level. The children with spastic cerebral palsy are unable to move and perform daily life tasks because there are sensory processing deficits (SPDs). If the children are unable to get the sensory input, then there is increased functional problem in children. Sensory processing is very important for the

development of the children (Pavão et al., 2021). The children are said to be a healthy if he/she receive proper motor and cortex signal and perform proper muscle movement and postural control. Postural control is the capacity to maintain the body position and our vestibular system is responsible for regulate the muscle tone and control the posture (Pavão et al., 2013). If the children with sensory issue in the processing of vestibular and proprioceptive, also deficit in the registration pattern of sensory processing, then vestibular stimulation therapy is given to the child for proper posture control and motor signal functioning.

There is dearth of population-based studies in India addressing SPDs in children with CP. Further, implementation of sensory based therapies may be beneficial in rehabilitation of these children. Therefore, the present study was undertaken to determine the SPDs in children with spastic CP and to evaluate the effect of vestibular stimulation therapy on balance and gross motor function in children with Spastic CP.

Methodology:

Phase I was a descriptive, cross sectional, multicentered study conducted between April 2021 and September 2023, in 230 caregivers of children with spastic CP, aged 3 to 14 years using Child Sensory Profile-2 (CSP-2) caregiver questionnaire. The enrolment of caregivers of children with spastic CP was done using non-probability snowball sampling method. Caregivers visiting various rehabilitation centers. The informed consent was obtained before the inclusion as per approval by the Ethics Committee (No.-DPSRU- BREC/2021/A/035) and CTRI registration (No. CTRI/2021/10/037537).

The validity and reliability of the CSP-2 caregiver questionnaire were checked for various items. For validity, face and content validity was determined. For reliability, internal consistency of all the responses was examined using Cronbach's alpha reliability coefficient.

Spastic CP were classified into diplegia, hemiplegia and quadriplegia and five Gross Motor Function Classification System (GMFCS) levels. The difference in prevalence and distribution of SPDs among these CP subtypes and GMFCS levels

was done. The, Chi-square test was used to find the difference among subtypes of spastic CP and GMFCS levels.

Phase II was a randomized, two arm parallel prospective study. A total of 80 children with bilateral spastic CP equally divided into two groups (40) each, were treated with Vestibular Stimulation Therapy (VST), and Conventional Physiotherapy Treatment (CT) for 3 days per week for 8 weeks. Children aged 6 to 12 years diagnosed as bilateral spastic CP with GMFCS level III, scoring in the range of "Definite" SPDs on Movement and Body Position domain of sensory section of CSP-2 caregiver questionnaire were included in the study. Children were excluded if diagnosed with athetoid, ataxic, hypotonic CP, having uncontrolled epilepsy, vision or hearing impairments, history of surgical interventions or injection (Botulinum Toxin injection), soft tissue release, six months prior to the study. The data were first analyzed for the normality and Two-way ANOVA (Mixed Design) 's test was used to find out the interaction between the two groups and intervention followed by Independent-t test for mean difference comparison of intergroup.

Results:

In the Phase I we found that, the Registration pattern was the highest for all the subtypes of spastic CP. We found that majority of caregivers reported a higher score among "Body Position" and "Movement" processing than other sensory sections for all the subtypes of spastic CP. The "Avoiding" pattern was also prevalent but only in Children with spastic quadriplegic CP. Also, high prevalence was reported for the "Social-emotional" domain among children with spastic quadriplegics. By comparing the children with spastic CP with respect to GMFCS level, we observed that children with higher level of GMFCS (III, IV and V) had higher affection of "Body Position" processing domain and lower level of GMFCS had higher affection of "Movement" processing domain.

Phase II data revealed statistically significant improvement in VST than control CT. Maximum improvement seen in "Body Position" processing with highest mean difference (-43.01 ± 5.56) in VST group than in CT group (-27.50 ± 2.59). Improvement in "Movement Processing" (-19.00 ± 5.85) is also significantly different from CT group (-3.38 ± 2.81). Pediatric Balance Scale also revealed statistically significant difference in VST group with higher mean difference (9.00 ± 2.66) than

CT (2.08 ± 1.16). GMFM also showed significant improvement in VST group (2.14 ± 0.70) than CT group (10.69 ± 0.66).

Conclusions:

It has been concluded that one of the most important components influencing functional skills in children is sensory processing. In children with CP, sensory processing is an essential element for motor and postural control. Sensory processing deficits are exceedingly prevalent among children with spastic CP. It is critical to gain a deeper comprehension of how sensory processing deficits are distributed in CP children. To enable the rehabilitation specialists to incorporate sensory-based interventions in the treatment of children with spastic CP, a thorough screening for sensory processing deficits are essential. This will facilitate the overall development CP children, hence increasing their participation in society.

Vestibular stimulation therapy act as a sensory supplementary stimulation in order to escalate arousal level, movement exploration, motor control and development, reflex integration and functional balance in children with CP. It is suggested to apply vestibular intervention in treatment protocol for children with CP to amend their therapeutic process. Therapies including sensory component must be provided by a well trained and experienced therapist as children with CP present neuromotor deficits as well as sensory processing deficits. Although more studies are required, vestibular intervention is recommended for the spastic children with CP for the improvement in motor functions.

Future Recommendations:

It is recommended that CSP 2 should be translated into Indian languages, for the evaluation of SPDs in the Indian pediatric population. Further, evaluation of SPDs in children with CP other than spastic with a large sample size may be carried out. Correlation of the location and size of brain lesions with the GMFCS level, given the dependency of SPDs on these factors may also be done. Further, there is a need for investigation of the distribution of SPDs across various cognitive levels of children with CP for better understand of their association. Finally, there is requirement of a study for the investigation of effect of vestibular stimulation on gait parameters in children with GMFCS levels I and II.

Limitations:

One of the limitations of our study was the outlooks of caregivers, which might diverge based on their beliefs, traditions and ethics may subsequently affect the responses to the items in CSP-2. The study was restricted to caregivers who understand English. The subjects included in Phase II were limited to bilateral spastic CP with GMFCS level III.

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LIST OF PUBLICATIONS

- **Dhiman, S**., Ajmera, P., Goyal, R. K., Gulati, S. (2025). Psychometric properties of Child Sensory Profile-2 (CSP-2) among Children with Spastic Cerebral Palsy. *European Journal of Pediatrics*, 184(1), 121.
- **Dhiman, S.**, Kundra, S., Jha N., Goyal, R. K., Ajmera, P., Gulati, S. (2024). Sensory Processing Issues in Children with Cerebral Palsy– A Systematic Review. *Current Developmental Disorders Reports*, 12(1), 1-14.
- Mittal, R., **Dhiman, S.**, Ahmed, S., Sharma, R., Khan, M. H., Ajmera, P., ... & Gulati, S. (2024). Impact of sensory-based therapy on problems with balance and posture in children with cerebral palsy: a systematic review and meta-analysis. *Discover Public Health*, 21(1), 1-13.
- **Dhiman, S**., Goyal, R. K., Mahesan, A., Ajmera, P., Ganesh, G. S., & Gulati, S. (2024). Prevalence of Sensory Processing Deficits in Children with Spastic Cerebral Palsy- An Indian Caregiver's Perspective. *Indian Journal of Pediatrics*, 91(11), 1177-1180.
- **Dhiman, S.**, Sahu, P. K., Reed, W. R., Ganesh, G. S., Goyal, R. K., & Jain, S. (2020). Impact of COVID-19 outbreak on mental health and perceived strain among caregivers tending children with special needs. *Research in developmental disabilities*, 107, 103790.